Weibull Analysis and Zero-time Failures

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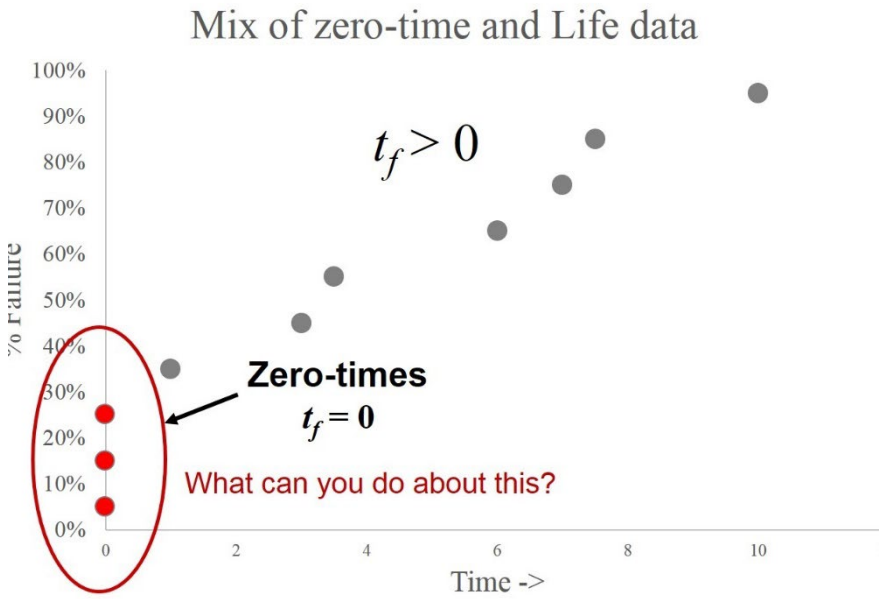
What Are Your Data Analysis Options?



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Intro to Aptiv: Customer Satisfaction

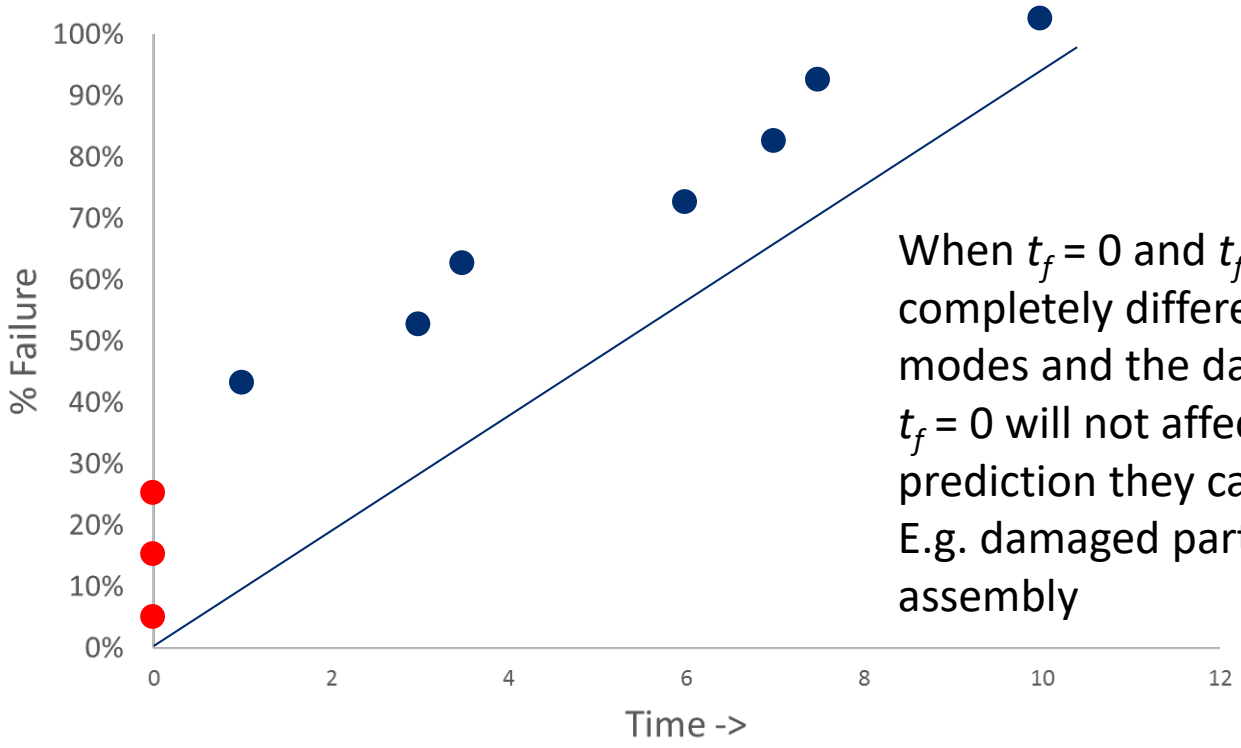
- Aptiv is a global technology company that develops safer, greener and more connected solutions enabling the future of mobility. Headquartered in Dublin, Aptiv has approximately 150,000 employees and operates 14 technical centers, as well as manufacturing sites and customer support centers in 45 countries. Visit aptiv.com

- The function of Aptiv's Customer Satisfaction department includes the task of assessing and forecasting customer risk due to field warranty failures. While many tools are used to achieve this task, ReliaSoft software products (Synthesis Platform) are the tool of choice.

Challenge/project scope

- Field return data often contains zero-time failures ($t_f = 0$), which often come in a mix with other life data ($t_f > 0$) and usually presents a challenge to the analyst
- Zero-time failures can be result of
  - out-of-box
  - assembly line
  - screen test after assembly
  - other types of failure that occur before a product begins its field operation
- There is no 'conventional' approach to processing zero-time failures
- There are a number of different ways to deal with zero-time failures. To select the correct approach one must have knowledge of:
  - failures modes and root cause
  - relevance to field failures
  - manufacturing tests
  - when a products degradation starts

Approach 1: Ignore Zero-times Failures



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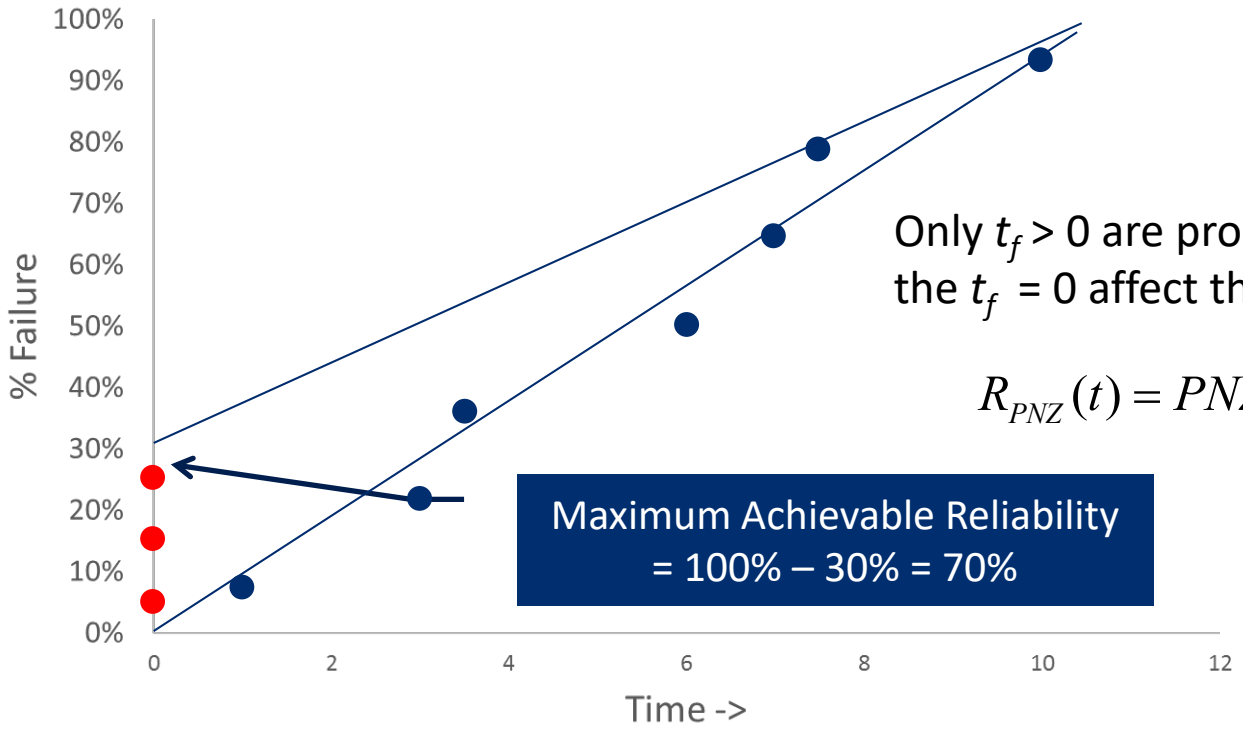
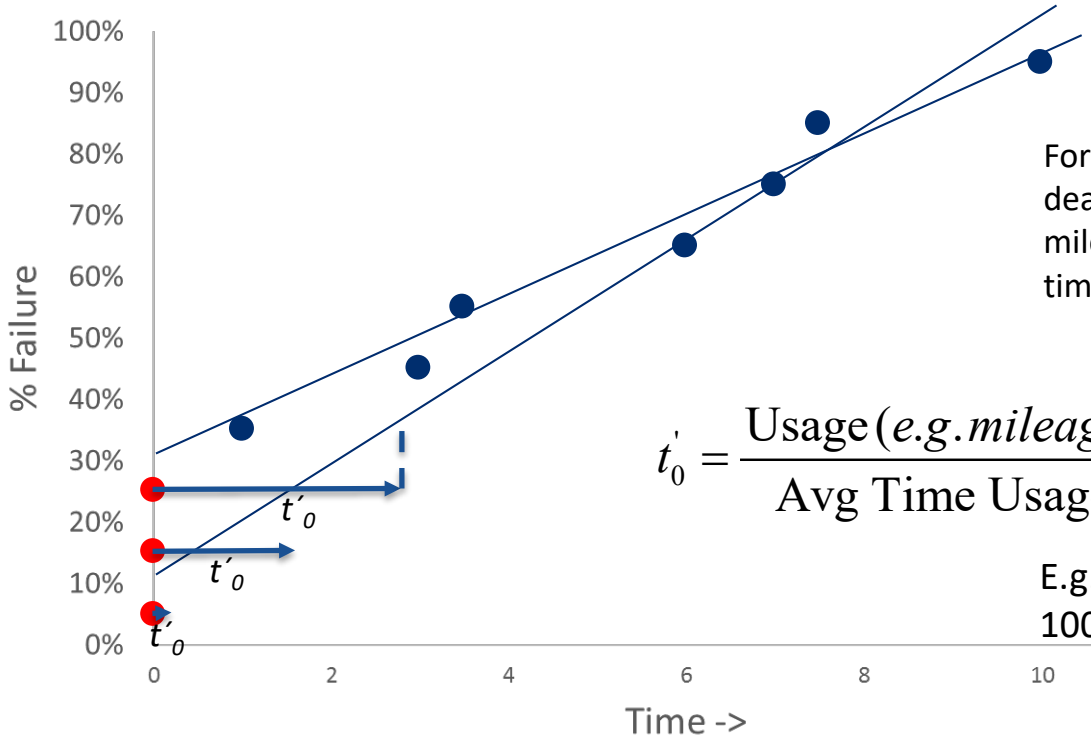
Approach 2: PNZ=Percent Non-Zero (Implemented in Weibull++)



Only $t_f > 0$ are processed, but the $t_f = 0$ affect the reliability

$$R_{PNZ}(t) = PNZ \times R(t)$$

Approach 3: Usage vs. Time

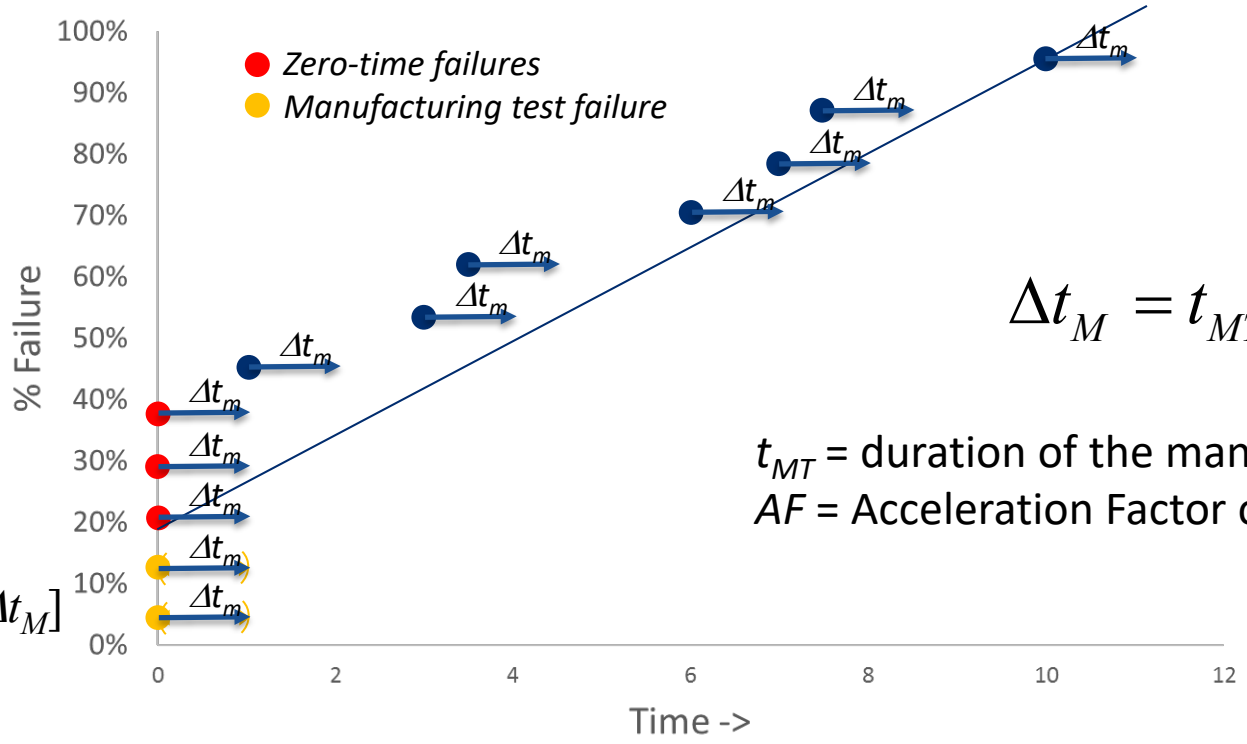


For example, a vehicle at a dealership has accumulated mileage that can be converted to time in the field

$$t_0' = \frac{\text{Usage}\,(e.g.\,mileage)}{\text{Avg Time Usage}}$$

E.g. 100 miles odometer:
100mi/32.9 mi/day = 3.04 days

Approach 4: Manufacturing Tests



t_0'=[0; Δt_M]

Manufacturing test failures can be correlated to those observed in the field

$$\Delta t_M = t_{MT} \times AF$$

t_{MT} = duration of the manufacturing test
AF = Acceleration Factor of the test

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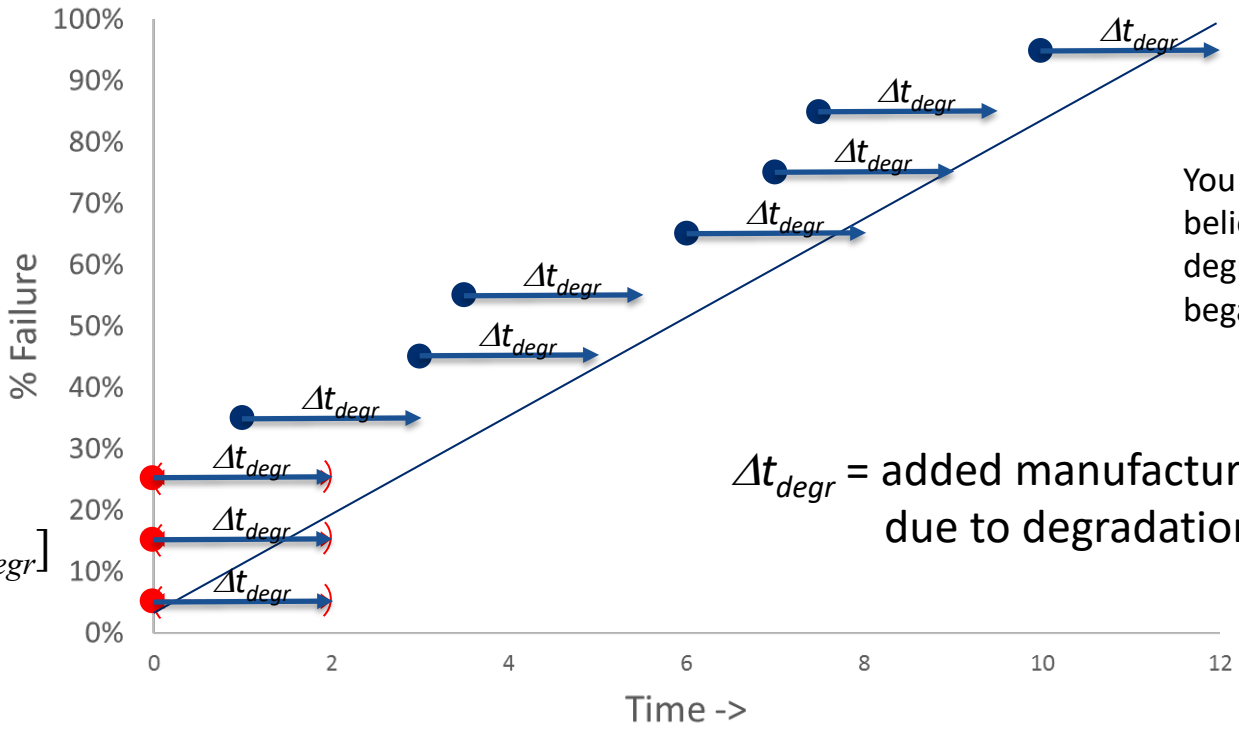
Approach 5: Early degradation



t_0'=[0; Δt_{degr}]

You have the reasons to believe that the parts degradation process began before $t_f = 0$

Δt_{degr} = added manufacturing time due to degradation

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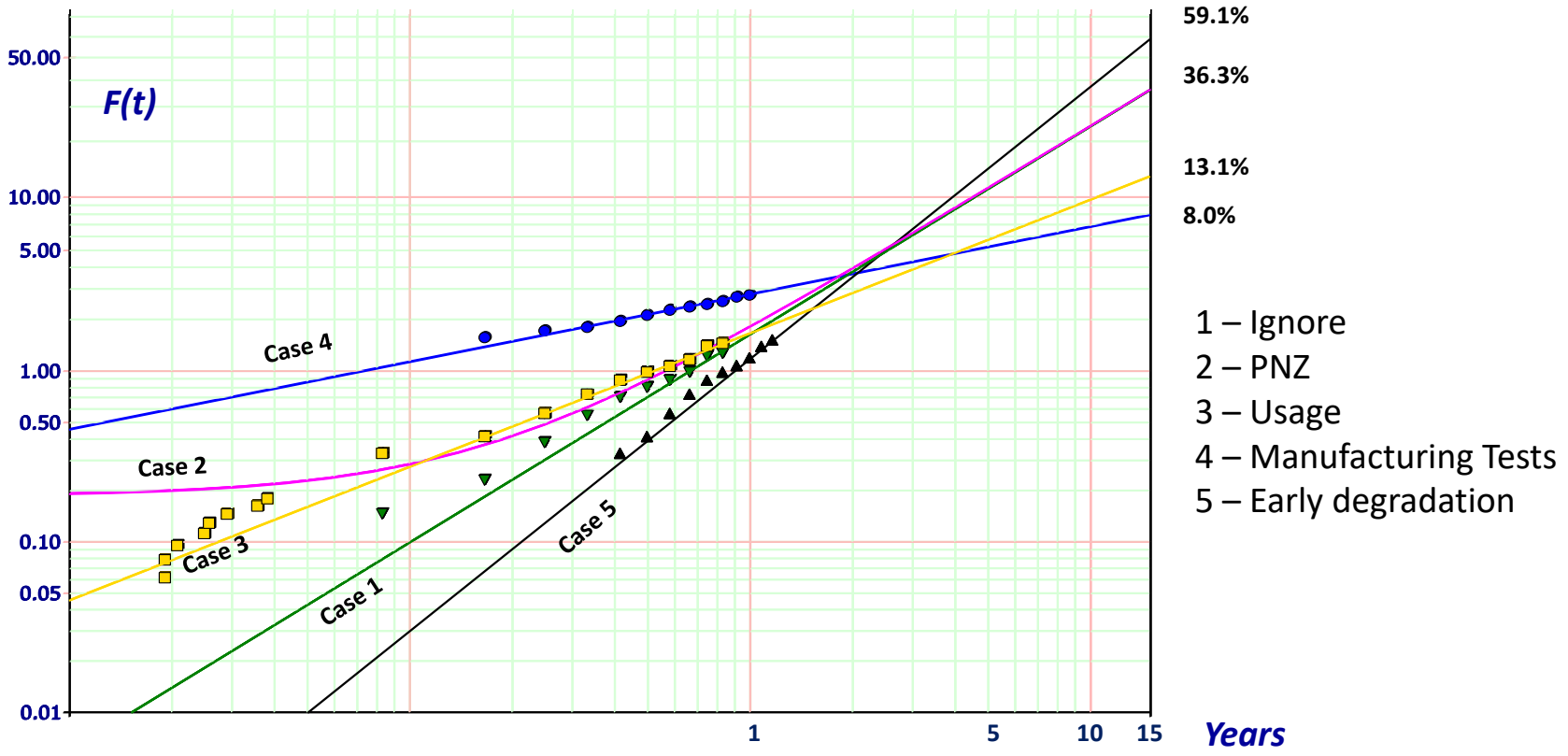
Using Synthesis Platform for Weibull++

- Weibull++ used to estimate the failure distribution parameters for each approach
- Using Weibull++ allowed for:
  - Manipulation of data using Nevada-Life Data transfer feature
  - Comparison of results using multiplot



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Summary

Challenge

Processing zero-time failures in life data analysis can be a challenging task with much uncertainty.

There is no established method of how and when to include time-zero data for life analysis.

Solution

The choice of the method affects the final results and may vary greatly.

The key to making a correct decision and therefore obtaining the most accurate prediction is in understanding the failure modes, their root causes, relevance to the field and other accompanying factors, such as manufacturing tests, stress screening, and accumulated time of the degradation, among others.

Results

Weibull++ provided the tools needed to quickly analyze different approaches for handling zero-time data. The available tools made it easy to manipulate data (Nevada-Life Data Transfer) and display multiple scenarios for results comparison (Multiplot).

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